

formations are further removed from their physiological correlates (than the psychical elements), and this removal is greater the more complex the psychical compounds become. And it is just at this point that psychology as an independent science in the proper sense of the word takes up its task." That is to say, it is the task of psycho-physics to discriminate the elements of our psychical processes and to discover their physiological correlates, but it is the task of psychology proper to discover the purely psychical laws of the synthesis of these elements—a task which would remain to be carried out, though the workings of the brain "stood as clearly exposed to our eyes as the mechanism of a watch."

Wundt then formulates four such fundamental psychical laws or principles, of which the first and most important is the "principle of creative resultants," the principle "that the product arising from any number of psychical elements is more than the sum of those elements . . . it is a new formation incomparable in all its essential attributes with the factors that contribute towards it." So "a clang is more than the sum of its partial tones." "In the same way every spatial percept is a product in which certain elements (the local signs) have yielded up their independence to impart to the product an entirely new property, namely, the spatial ordering of the sensations. In binocular vision the separate images of the two organs of vision disappear, to give rise in the common resultant image to the immediate perception of solidity and depth." On the other hand, the neural correlates of these elements remain a spatially ordered manifold, exhibiting no corresponding fusion or synthesis. The acceptance of this principle is of the first importance for the progress of physiological psychology, but whether it is compatible with adhesion to the doctrine of psycho-physical parallelism, as Wundt maintains, may be seriously questioned, as also whether it can properly be called a principle of psychical causation. It seems clear that if with Wundt we recognise this and the other psychical laws that he formulates, whether or not we admit them as principles of psychical causation, we cannot maintain the principle of psycho-physical parallelism in the rigid form in which it is so widely current at the present time.

It is a pleasure to welcome the appearance of the first part of an English translation of this great work. Prof. Titchener has accomplished this part of his difficult task with all the care and skill which his previous labours in this line have prepared us to expect.

In spite of the title of this work, it is as much a treatise on experimental as on physiological psychology, and in view of the common misconceptions of the relations of experimental to other methods in psychology the following quotation may fitly conclude this brief notice:—"We now understand by 'experimental psychology' not simply those portions of psychology which are directly accessible to experiment, but the whole of individual psychology. For all such psychology employs the experimental method: directly, where its direct use is possible; but in all other cases indirectly, by availing itself of the general

results which the direct employment of the method has yielded, and of the refinement of psychological observation which their employment induces."

W. McD.

RADIUM AND RADIO-ACTIVITY.

Radium Explained. By Dr. W. Hampson, M.A. (Jack's Scientific Series.) Pp. x + 122. (Edinburgh and London: T. C. and E. C. Jack, 1905.) Price 1s. net.

THIS little book, which is sold for the modest price of one shilling, will, we think, serve a useful purpose in giving an elementary acquaintance with the subject of radio-activity, so far as that is accessible to those with little scientific knowledge. The explanations given of the experimental properties of radium are, so far as we have observed, clear and accurate, and the get-up of the book, though not superb, is respectable. Probably one of the most valuable chapters in the book is that on the medical aspects of radium, and its possible uses in the cure of disease, for few writers on radio-activity generally are competent to discuss this part of the subject. Dr. Hampson is of opinion that the medicinal value of mineral waters is connected with their radio-activity. This question, we think, should easily be susceptible of a definite and conclusive answer. There would not be the slightest difficulty in giving baths of weak radium solution more potent by far than the richest mineral waters. Why not test the medicinal value of these? It is really urgent that this experiment should be tried by competent hands.

It is, we think, to be regretted that Dr. Hampson has plunged into an attack on modern views of the constitution of matter, as expounded by Prof. J. J. Thomson, Sir Oliver Lodge, and others. We have read these criticisms with the attention due to a worker like Dr. Hampson, who has done good service in the cause of science, but cannot admit that they possess any validity. To go fully into the questions which he raises would take us beyond the limits of this notice, but we may briefly discuss one or two of the points. At the outset, Dr. Hampson objects to the definition of mass by means of inertia. Mass, he says, is quantity of matter; inertia is dependent on velocity as well as on mass.

It is true, no doubt, that the definition of mass as quantity of matter may be found in some old-fashioned text-books of repute. But such a definition has no value, for how is the quantity of matter to be ascertained? The choice practically lies between defining mass by inertia at a given speed or by gravity. So far as is known, exactly the same ratio between two masses of ordinary matter will result, whichever method of comparison is adopted. As, however, gravity depends on local circumstances, while inertia (at given velocity) does not, the latter property is preferred for the definition of mass, as being more fundamental.

No doubt, before it can be granted that the electron theory fully accounts for the observed properties of matter, it will be necessary to show that it will explain the phenomena of gravitation. This, at present, it

makes no pretence of doing, as, of course, its distinguished authors would at once admit. But mass, as we have seen, is not conventionally defined with reference to gravity, but by means of inertia, or momentum at unit velocity. As a moving electric charge can be shown to possess this momentum, it is a strictly correct use of words to say that the electron theory explains the property of mass.

Dr. Hampson argues, in the second place, that electricity is a form of energy, and that it cannot therefore be identified with matter.

"When an electrical machine . . . is used to charge a Leyden jar . . . there is no change in the quantity of material substance with which operations were started; it is the mechanical energy driving the machinery that has been converted into electricity" (p. 87).

The misconception here lies in confusing the separation of positive and negative electricity with the creation of either. Take the case of a Leyden jar. The coatings of the jar, according to modern views, initially both contain a number of chemical atoms, all with their normal complement of constituent electrons. The operation of charging consists in the removal of some of these electrons from the outer coating, say, and their transference to the inner one. This leaves the outer coat with a defect of electrons, and therefore positively charged, while the inner one acquires an excess of them, and consequently becomes negatively charged. The transference involves the expenditure of energy on the electrons, but no alteration in their number, and therefore no change in the amount of matter concerned.

We are sorry to have had to dwell principally on the parts of the book with which we disagree, as these are but a small portion of the whole, and do not detract from the usefulness of the rest.

R. J. S.

OIL FUEL.

Oil Fuel: Its Supply, Composition and Application.

By S. H. North. Pp. viii + 152. (London: Chas. Griffin and Co., Ltd., 1905.) Price 5s. net.

MR. SYDNEY H. NORTH has utilised the store of data collected whilst he was editor of the *Petroleum Review* to supply a most valuable addition to Griffin's scientific text-books in his work on "Oil Fuel" and to give his readers a concise and valuable record of the developments in the use of liquid fuel for the generation of power.

In the first chapter of the book he deals with the distribution and sources of supply of petroleum, and points out that the chief sources are now so geographically situated as to place the United Kingdom at a disadvantage in case of war, should the use of liquid fuel be largely adopted in the Naval Service, a fact which accentuates the importance of developing such fields as those of Canada and Burmah, and also of opening up new areas where possible in British Possessions.

In concluding this portion of the work, the author expresses his opinion that recent developments and extensions of oil-bearing areas are now progressing

so rapidly that it is quite within the bounds of possibility that the liquid-fuel question may in the near future be placed above the control of price and geographical position.

In dealing with the economic aspect of liquid fuel it is pointed out that although the enormous advantages accruing from its use were early recognised, the prohibitive price prevented any great advance in its use, but that with the increase in output its utilisation now comes within the range of practical possibility, and that the advantages in winning, transporting, and storing and using the oil, especially for marine purposes, are so great that the supply of the liquid fuel is now the only factor checking its universal introduction.

In considering the absolute economy as a fuel, the author very properly leaves out the extravagant claims made by some of the early experimentalists, and only gives the best authenticated values, which vary from 12.5 to 16 lb. of water evaporated per lb. of liquid fuel. Variations in the use of oil as a fuel are of course largely dependent upon the method by which the oil is burnt, and too little stress is put upon the importance of the space factor, which is a most essential one, as, given plenty of combustion space in the boiler, the smokeless burning of liquid fuel is a perfectly simple problem, which, however, increases enormously in difficulty as the available space becomes more and more cramped.

The chapter on the chemical composition of fuel oils gives an excellent summary of analytical results, and this ends with a table showing the composition, calorific value and evaporative power of different descriptions of British coal. This, however, is liable to lead to misconception, as the value expressed in lb. of water evaporated per lb. of fuel is calculated, and not that obtained in practice, so that the reader who finds that by this table 1 lb. of Welsh coal will evaporate 14.98 lb. of water will be a little puzzled to see where the large economy comes in, when 1 lb. of oil only evaporates from 12.5 to 16 lb. of water. As a matter of fact, all recent work points to the relative evaporative results under the best conditions being 9 lb. of water per lb. of coal, or 15 lb. of water per lb. of oil, whilst the theoretical results give 14.98 lb. of water for coal, and 20 to 21 lb. for oil.

The section dealing with the conditions of combustion in oil furnaces is a useful reproduction of the views expressed by Messrs. Ord, Paul, and Lewes, and the author does not venture on any generalisation of his own.

Turning from consideration of the oil itself to the methods of burning it, the author gives a very useful historical summary of the early experiments down to the year 1883, when Mr. James Holden, whose name will always be inseparably connected with the subject of liquid fuel, introduced his method of consuming the oil on the Great Eastern Railway.

A chapter is then devoted to modern burners and methods, and steam, air, and mechanical injectors are discussed. The author very properly concludes that

"for the successful use of liquid fuel it appears to be a *sine qua non* that auxiliary apparatus